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VERIFICATION OF TRANSLATION

I, Kouichi Kunimune, a translator of c/o Subaru Patent Office, Kojimachi Koyo Bldg., 10, Kojimachi 1-chome, Chiyoda-ku, Tokyo, Japan, hereby declare:

1. that I know well both the Japanese and English languages;

2. that the attached English translation is a true and correct translation of Japanese Patent Application No. 2000-143672 filed on May 16, 2000, priority of which is claimed in USSN 09/837,102 filed on April 18, 2001, to the best of my knowledge and belief; and

3. that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 USC 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: February 3, 2003

By: Kouichi Kunimune

Kouichi Kunimune

PATENT OFFICE

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number: Patent Appln. No. 2000-143672

Applicant(s): CHISSO CORPORATION

CHISSO POLYPRO FIBER CO., LTD.

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[Article]	Drawing(s)	1
[Article]	Abstract	1
[Proof]	Yes	

[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] Filter Cartridge

[SCOPE OF CLAIM FOR PATENT]

[CLAIM 1] A filter cartridge which is prepared by winding a non-woven fabric strip comprising a thermoplastic fiber around a perforated cylinder in a twill form, wherein in winding in a twill form, a number (W) of winding the non-woven fabric strip from one end to the other end in a longitudinal direction of the perforated cylinder is one to 10 per a length of 250 mm in the perforated cylinder.

[CLAIM 2] The filter cartridge as claimed in claim 1, wherein when a 2-fold value (2W) of the winding number (W) is represented by a fraction having a denominator of two figures or less which is a non-reducible approximate value, the denominator is 4 to 40.

[CLAIM 3] The filter cartridge as claimed in claim 1 or 2, wherein the non-woven fabric strip has a width of 0.5 to 40 cm.

[CLAIM 4] The filter cartridge as claimed in any one of claims 1 to 3, wherein a product of a width (cm) and a basis weight (g/m^2) of the non-woven fabric strip is 20 to 200.

[CLAIM 5] The filter cartridge as claimed in any one of claims 1 to 4, wherein the non-woven fabric strip is of a long fiber non-woven fabric which is thermally bonded in at least a part of fiber intersections.

[CLAIM 6] The filter cartridge as claimed in claim 5, wherein the long fiber non-woven fabric is produced by a spun bonding method.

[CLAIM 7] The filter cartridge as claimed in any one of claims 1 to 4, wherein the non-woven fabric strip is of a melt blown non-woven fabric.

[CLAIM 8] The filter cartridge as claimed in any one of claims 1 to 4, wherein the non-woven fabric strip is produced by laminating a long fiber non-woven fabric in which at least a part of fiber intersections is thermally bonded with a melt blown non-woven fabric into a laminated non-woven fabric having two layers or more.

[CLAIM 9] The filter cartridge as claimed in any one of claims 1 to 8, wherein the filter material of the filter cartridge has a void rate of 65 to 85%.

[THE DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field of the Invention]

The present invention relates to a cylindrical filter cartridge for filtration of liquid.

[0002]

[Prior Art]

Various filters for clarifying a fluid are presently developed and produced. Among them, cartridge-type filters (hereinafter called filter cartridges) are widely used in the industrial field, for example, for removing suspended

particles in industrial liquid materials, removing cakes flowing out of a cake filtering apparatus and clarifying industrial water.

[0003]

Several kinds of structures of a filter cartridge have so far been proposed. The most typical one is a bobbin winder-type filter cartridge, which is a cylindrical filter cartridge prepared by winding a spun yarn as a filter material on a perforated cylindrical core in a twill form and then fluffing the spun yarn. This type has long been used due to inexpensiveness and easiness in production.

[0004]

Such conventional filter cartridge as the bobbin winder-type filter cartridge have several defects. For trapping foreign matters by means of fluffs of fluffed spun yarns and also in gaps of the spun yarns, it is difficult to control the size and form of the fluffs and gaps. This limits size and amount of the foreign matters that can be trapped. Further, constitutional fibers of a spun yarn, which is made from short fibers, fall away when fluid flows onto the filter cartridge. In addition, a spun yarn is produced by spinning short fibers as already mentioned, for which at least two steps of forming and spinning short fibers are required. Thus, use of the spun yarn will sometimes increase a price of the product.

[0005]

Several methods have been proposed in order to solve such problems of conventional filter cartridges. For example, JP-A 51-34469 proposes a process in which a filter cartridge is produced using a fiber sliver in stead of the spun yarn, and it is thermally hardened with a hardener such as urea resins. However, this process is intended to improve a particle trapping performance, and therefore, it cannot solve the above problems.

[0006]

Japanese Utility Model Application Laid-open No. 54-36878 proposes a filter in which a cellulose non-woven fabric tape is used instead of the spun yarn, and there is no possibility of binder elusion, and further, both the material and production cost are inexpensive. However, the filter cannot solve the above problems, also.

[0007]

Japanese Utility Model Publication No. 6-7767 proposes a filter cartridge in which a filter material obtained by squashing a tape-shaped paper having porosity while twisting, thereby squeezing it to control a diameter thereof to about 3 mm is wound around a porous internal cylinder in a close twill. This method is advantageous in that a winding pitch can be gradually increased from the porous internal cylinder toward the outside. However, the filter material needs to be squashed and squeezed, so that foreign matters are trapped primarily between the winding pitches of the filter material. Accordingly, it is less expected to trap foreign

matters by the filter material itself as is the case of a conventional bobbin winder type filter using spun yarns which traps foreign matters by means of fluffs. This blocks the surface of the filter to shorten the filter life or brings about the poor liquid-passing property in a certain case.

[0008]

Similar inventions are disclosed in Japanese Patent Publication No. 1-25607, Japanese Utility Model Publication No. 3-52090 and JP-A 1-317513. However, these are those intend to improve water absorption property, oil absorption property and antifungal property, and therefore, they cannot solve the above problem.

[0009]

Further, JP-A 1-115423 proposes a filter in which strings obtained by slitting a cellulose spun bonded non-woven fabric into strips and passing them through narrow holes to twist them are wound around a bobbin having a lot of drilled pores. It is considered that this method shall make it possible to prepare a filter having a higher mechanical strength and being free of dissolution in water and elution of a binder, as compared with a conventional roll tissue filter prepared by winding tissue paper in a roll form, which is produced from α-cellulose prepared by refining a coniferous pulp. However, the cellulose spun bonded non-woven fabric used for this filter has a papery form and thus a too high rigidity. Further, the cellulose

spun bonded non-woven fabric is liable to swell in a liquid due to its papery form. Swelling may bring about various problems such as a decrease in a filter strength, a change in a filtering accuracy, a deterioration in a liquid-passing property, a reduction in a filter life and the like. Adhesion at fiber intersections of the cellulose spun bonded non-woven fabric are mostly conducted by a certain chemical treatment. Such adhesion is often unsatisfactory, causing a change in a filtering accuracy or falling of fiber chips, so that a stable filtering performance is difficult to achieve.

[0010]

Further, JP-A 4-45810 proposes a filter prepared by winding a slit non-woven fabric comprising composite fibers in which 10% by weight or more of structural fibers is divided ones of 0.5 denier or less on a porous core cylinder to provide the fiber density of 0.18 to 0.30 g/cm^3. This method is advantageously used to trap fine particles contained in a liquid by means of fibers having a high fineness. However, in order to divide the composite fibers, a stress needs to be applied using, for example, high-pressure water, and it is difficult to evenly divide the fibers all over the non-woven fabric by means of high-pressure water processing. If not evenly divided, there occurs a difference in a trapped particle diameter between a well-divided portion and an insufficiently divided portion of the non-woven fabric, and this may lower the filtering accuracy. Further, the stress applied for dividing

sometimes lowers a strength of the non-woven fabric, and this may cause reduction of the resulting filter strength and frequent deformation of the filter during use; or possible change of the void ratio of the filter may reduce the liquid-passing property. JP-A 4-457811, Japanese Utility Model Application Laid-open No. 4-131412, Japanese Utility Model Application Laid-open No. 4-131413, Japanese Utility Model Application Laid-open No. 5-2715 and Japanese Utility Model Application Laid-open No. 5-5-18614 are the similar patent or utility model. However, divided fibers are used in all of these filters so that the above problems cannot be solved.

[0011]

Furthermore, US 6,054,216 proposes a process in which a melt blown non-woven fabric having a width of 2.5 to 16 cm and a fiber radius of 0.5 to 10 μm is wound around a string for enforcement with twist to make into an enforced string which is wound around to result a filter cartridge. As a melt blown non-woven fabric is only wound around a string for enforcement regarding to the method, it is difficult to keep a constant filtration capability because the melt blown non-woven fabric is divided from the string for enforcement if flow speed of filtration liquid is too fast, or filtration accuracy may be varied when twist of the melt blown non-woven fabric comes loose.

[0012]

[Problems to be Solved by the Invention]

An object of the present invention is to provide a cylindrical filter cartridge which is improved in a filter life and liquid-passing property and is prevented from occurrence of dropped matters, those have been problems for the conventional filter cartridge.

[0013]

[Means for Solving the Problems]

The present inventors have conducted intensive researches and, as a result, found that the problems described above can be solved by a cylindrical filter cartridge, which is prepared by winding a non-woven fabric strip on a perforated cylinder in a twill form, in which a number of winding is specified, and can be obtained a filter cartridge having an extremely excellent filtration performance. This finding has led to the present invention.

[0014]

The present invention is composed of:

(1) A filter cartridge which is prepared by winding a non-woven fabric strip comprising a thermoplastic fiber around a perforated cylinder in a twill form, wherein in winding in a twill form, a number (W) of winding the non-woven fabric strip from one end to the other end in a longitudinal direction of the perforated cylinder is one to 10 per a length of 250 mm in the perforated cylinder.

[0015]

(2) The filter cartridge as described in item (1), wherein when a 2-fold value (2W) of the winding number (W) is

represented by a fraction having a denominator of two figures or less which is a non-reducible approximate value, the denominator is 4 to 40.

[0016]

(3) The filter cartridge as described in item (1) or (2), wherein the non-woven fabric strip has a width of 0.5 to 40 cm.

[0017]

(4) The filter cartridge as described in any one of items (1) to (3), wherein a product of a width (cm) and a basis weight (g/m^2) of the non-woven fabric strip is 20 to 200.

[0018]

(5) The filter cartridge as described in any one of items (1) to (4), wherein the non-woven fabric strip is of a long fiber non-woven fabric which is thermally bonded in at least a part of fiber intersections.

[0019]

(6) The filter cartridge as described in item (5), wherein the long fiber non-woven fabric is produced by a spun bonding method.

[0020]

(7) The filter cartridge as described in any one of items (1) to (4), wherein the non-woven fabric strip is of a melt blown non-woven fabric.

[0021]

(8) The filter cartridge as described in any one of items (1) to (4), wherein the non-woven fabric strip is produced

by laminating a long fiber non-woven fabric in which at least a part of fiber intersections is thermally bonded with a melt blown non-woven fabric into a laminated non-woven fabric having two layers or more.

[0022]

(9) The filter cartridge as described in any one of items (1) to (8), wherein the filter material of the filter cartridge has a void rate of 65 to 85%.

[0023]

[Preferred Embodiment of the Invention]

The embodiment of the present invention shall be explained below in detail.

The filter cartridge of the present invention is prepared by winding a non-woven fabric strip comprising a thermoplastic fiber on a perforated cylinder in a twill form. In the present invention, the non-woven fabric strip means a non-woven fabric having a narrow width, which is prepared by slitting (cutting) a wide non-woven fabric or produced directly in a narrow width. It is preferable that a wide non-woven fabric is slit in order to obtain the stable quality at low cost. An optimum width and basis weight of a non-woven fabric to be used shall be described later.

[0024]

In the present invention, the thermoplastic fiber means a fiber produced from a thermoplastic resin. All thermoplastic resins capable of being melt-spun can be used for the thermoplastic resin used in the present invention.

Examples include polyethylene resins such as low density polyethylene, high density polyethylene and linear low density polyethylene; polypropylene resins such as polypropylene and copolymerized polypropylene (for example, binary or multi-component copolymers comprising propylene as a primary component with ethylene, butene-1, 4-methylpentene-1 and the like); other polyolefin resins than the above polyethylene and polypropylene resins; polyester resins such as polyethylene terephthalate, polybutylene terephthalate and low melting polyesters copolymerized with addition of isophthalic acid besides terephthalic acid as an acid component; polyamide resins such as nylon 6 and nylon 66; and thermoplastic resins such as polystyrene, polyurethane elastomers, polyester elastomers and polytetrafluoroethylene.

[0025]

Functional resins can also be used so as to provide a filter cartridge with a biodegradability derived from biodegradable resins such as a lactic acid base polyester. Further, polyolefin resins and polystyrene resins which can be polymerized using metallocene catalysts are preferably used for a filter cartridge, taking advantage of the characteristics of metallocene resins such as improvements in a strength of a non-woven fabric and a chemical resistance, and a reduction in a production energy. Also, those resins may be blended for use in order to control a heat adhesion property and a rigidity of a non-woven fabric.

When a filter cartridge is used for filtering an aqueous solution of room temperature, polyolefin resins such as polypropylene and polyethylene are preferably used from the viewpoints of a chemical resistance and a cost. When used for a solution of a relatively high temperature, polyester resins, polyamide resins and syndiotactic polystyrene are preferred.

[0026]

Fibers other than thermoplastic fibers such as cotton, glass fiber and metal fiber can be used together as long as in a range in which they do not damage the function including the filter life, liquid-passing property of prevention from occurrence of falling off matters from the filter cartridge, those are characteristics of the filter cartridge of the present invention.

[0027]

In the present invention, a heat bonding method is preferred as a method for bonding fiber intersections for preparing the non-woven fabric from the thermoplastic fiber. The method includes a thermal compression bonding method by means of an apparatus such as a thermal embossing roll and a heat flat calendar roll; and a method using a heat treating machine of a hot blast-circulating type, a heat through-air type, an infrared heater type or a vertical hot blast-blowing type. Among them, a method using a thermal embossing roll is preferred, because it can elevate a

production rate of a non-woven fabric, provides a good productivity and can reduce a cost.

[0028]

Further, a non-woven fabric produced by the method using a thermal embossing roll has a part where strong thermal compression bonding by an embossing pattern is applied and another part where only weak thermal compression bonding by deviating from an embossing pattern is applied. This makes it possible to trap a lot of foreign matters in the part where strong thermal compression bonding is applied. On the other hand, a part of the foreign matters is trapped in the part where only weak thermal compression bonding by deviating from an embossing pattern is applied, while the remaining foreign matters can pass through the non-woven fabric to move to the following layer. Preferred is this deep layer-filtering structure, in which even the inside of the filter is utilized. In this case, an embossing patterned area is preferably from 5 to 25%. Setting the lower limit of this area to 5% can enhance the filtering effect exerted by fiber intersections by heat adhesion described above, and setting the upper limit to 25% can control the rigidity of the non-woven fabric not to become too high. Further, a part of foreign matters are allowed to pass through the non-woven fabric strip. Then the passed foreign matters are trapped at the inside of the filter, so that the filter life can be extended.

[0029]

A composite fiber comprising a lower melting resin and a higher melting resin, wherein the melting point difference is 10°C or more, preferably 15°C or more, is preferred as the fiber constituting the non-woven fabric strip because heat adhesion of the non-woven fabric strip is improved therefor. The melting point difference is not restricted on the upper end, but it may correspond to the melting point difference of a resin having the highest melting point and a resin having the lowest melting point. In the case of a resin having no melting point, the flow-starting temperature is defined as a melting point. When a composite fiber comprising a resin having a lower melting point and a resin having a higher melting point is used for fibers constituting the non-woven fabric strip, it becomes easy to adjust the degree of heat adhesion of the non-woven fabric strip, so that the void rate can be easily controlled in the edge part of the filter cartridge.

[0030]

A combination of the lower melting resin and the higher melting resin in the composite fibers shall not specifically be restricted as long as the melting point difference is 10°C or more, preferably 15°C or more, which includes linear low density polyethylene/polypropylene, high density polyethylene/polypropylene, low density polyethylene/polypropylene, copolymer of propylene with other α-olefin/polypropylene, linear low density polyethylene/high density polyethylene, low density

polyethylene/high density polyethylene, various polyethylenes/thermoplastic polyester, polypropylene/ thermoplastic polyester, copolymerized low melting thermoplastic polyester/thermoplastic polyester, various polyethylenes/nylon 6, polypropylene/nylon 6, nylon 6/nylon 66 and nylon 6/thermoplastic polyester.

[0031]

Among them, a combination of linear low density polyethylene/polypropylene is preferably used, since rigidity and a void rate of the non-woven fabric strip can readily be controlled during a step of adhesion of fiber intersections in producing the non-woven fabric. When a filter cartridge is used for filtering a solution of a relatively high temperature, a combination of low melting polyester/polyethylene terephthalate can suitably be used, the polyester being prepared by copolymerizing with isophthalic acid.

[0032]

In the present invention, the perforated cylinder functions as a core of a filter cartridge, and the material and the form thereof shall not specifically be restricted as long as it has a strength which is endurable to external pressure applied in filtering and the pressure loss is not markedly high. It may be, for example, an injection-molded article obtained by processing polyethylene or polypropylene into a net type cylinder as is the case with a core used for a conventional filter cartridge or ones obtained by

processing ceramics and stainless steel in the same manner. Alternatively, other filter cartridges such as a filter cartridge subjected to pleat-folding processing and a filter cartridge of a non-woven fabric-winding type can be used as a perforated cylinder.

[0033]

Next, a method for winding the non-woven fabric strip around a perforated cylinder shall be explained. One example of the producing method is illustrated in Figure 2. A winder conventionally used for a bobbin winder type filter cartridge can be used for the winding machine. A perforated cylinder 2 having a diameter of about 10 to 40 mm and a length of 100 to 1000 mm is installed to a bobbin 5 of this winder. After the non-woven fabric strip 4 converged matter passes through a yarn passage and a small hole of a traverse guide 6, it is wound around the perforated cylinder in one or two laps. The perforated cylinder and the end face of the non-woven fabric strip may be thermally bonded to ensure winding. The yarn passage of the winder is waved from A direction to B direction in twill form by means of a traverse cam 6 disposed parallel to the bobbin, so that the non-woven fabric strip is wound around the perforated cylinder while waving in a twill form. The diameter of the small hole varies depending on the basis weight and the width of the non-woven fabric used and falls preferably in the range of 3 to 10 mm. If this diameter is smaller than 3 mm, a friction between the non-woven fabric and the small

hole is increased, so that the winding tension becomes too high. On the other hand, the value larger than 10 mm may not render the converging size of the non-woven fabric stabilized.

[0034]

The winding conditions in this case can be set up according to those in producing a conventional bobbin winder type filter cartridge. Initial speed of the bobbin may be set to, for example, 1000 to 2000 rpm, and the feeding speed may be controlled to apply an appropriate tension while winding the non-woven fabric. The void rate of the filter cartridge is controlled by the tension in this case.

[0035]

The filtering accuracy can be changed by controlling a ratio of the traversing speed of the traverse cam to the rotating speed of the bobbin, thereby changing a number (hereinafter referred to as a winding number and represented by W) of winding the non-woven fabric strip around the perforated cylinder from one end to the other end in a longitudinal direction when winding the non-woven fabric strip in a twill form. That is, the winding number means a rotation number of the bobbin 5 while the traverse guide 6 moves from one end to the other end of the perforated cylinder 2 in a longitudinal direction. Accordingly, a value of W is not necessarily a natural number. The winding number should be very accurate, and therefore, a moving

distance of the traverse guide has to be geared to a rotation number of the bobbin so that this value should not get out of order.

[0036]

In the present invention, a winding number W is 1 to 10, preferably 2 to 8 and more preferably 3 to 5 per 250 mm of the perforated cylinder used for the filter cartridge. If this value is less than one, an angle of traversing becomes too large, and therefore the non-woven fabric strip is liable to get out of the perforated cylinder. On the other hand, if this value exceeds 10, an angle of traversing becomes too small, and the non-woven fabric strip is liable to get out of the perforated cylinder also in this case.

[0037]

A relation of the winding number to the filtering accuracy is well known in the case of a wound filter in which a spun yarn is used as a filtering material. In a conventional wound filter in which a spun yarn is used, a winding yarn (that is, a spun yarn) generally has a circular cross-sectional form, and a yarn diameter thereof is about 3 mm at the largest. Thus, the winding number and the pitch of the yarn in winding in a twill form can be represented by the following equations (1) and (2):

$$2 \times W = 2 \times W_0 \pm 1/N \qquad (1)$$

$$N = T/W_0/P \qquad (2)$$

[0038]

wherein W is a winding number; W_0 is a natural number approximate to the winding number W; N is an ordered number; T is a traverse width; and P is a pitch of the yarn. Among the above variables, W_0 and N are natural numbers, and W, P and T are arbitrary positive numbers. In general, as the pitch of the yarn becomes smaller, the wind filter having a finer accuracy is prepared. This equation can be applied to a yarn other than a spun yarn, for example, a split yarn.

[0039]

On the other hand, in the filter cartridge of the present invention, the non-woven fabric strip is used as a filter material in place of a spun yarn, and therefore the equations (1) and (2) cannot be applied as they are. The non-woven fabric is converged in winding as described above, so that a thickness of the yarn becomes far large as compared with that of a conventional spun yarn. Accordingly, even if the conditions of the equations (1) and (2) are satisfied, the yarns themselves are superposed and a filter cartridge having the intended accuracy is not obtained.

[0040]

After we, the inventors of the present invention, have carried out an intensive study, we have found that a filter cartridge, which is prepared by winding a non-woven fabric strip around a perforated cylinder in a twill form, exhibits an excellent filtering performance when a denominator M_n is a specific value in which the winding number is approximated by the following equation (3):

$$2 \times W \fallingdotseq X/M_n \qquad (3)$$

wherein X/M_n represent a non-reducible fraction, X and M_n are each independently natural numbers, and n represents a maximum figure of the number; for example, M_2 is an integer of 1 to 99.

[0041]

In the present invention, when a 2-fold value (2W) of the winding number (W) is represented by an approximate fraction having a non-reducible denominator of two figures or less, M_2 in the equation (3), i.e., a value of the denominator is 4 to 40, preferably 5 to 20. As the value of M_2 becomes larger, the filter cartridge having a finer texture is prepared. If this value is less than 4, a texture of the resulting filter cartridge is roughened too much, and it is likely that a filter cartridge end face is not smooth. On the other hand, if the value of M_2 exceeds 40, a texture of the filter cartridge becomes too fine, and it is likely that the liquid-passing property is reduced and the filter life is shortened.

[0042]

In this case, it is important that the value of 2W is approximated to a fraction having a denominator of a natural number of two figures or less. For example, when the winding number is 1.893, 2 × W is 3.786. When this 3.786 is approximated to a fraction having a denominator of one figure, it is 3 and 4/5 (this means a mixed fraction consisting of 3 and four fifths, and the same shall apply

unless otherwise described). Accordingly, when the winding number is 1.893, M_1 is 5 which is the denominator of 3 and 4/5. Similarly, when 2W is approximated to a fraction having a denominator of two figures or less, a value thereof is 3 and 11/14, and therefore M_2 is 14 which is a denominator of 3 and 11/14. Similarly, when 2W is approximated to a fraction having a denominator of three figures or less, it is 3 and 393/500, and therefore M_3 is 500. Accordingly, in this case, a value of M_2 in the equation (3) is 14 which is the denominator when approximated to a fraction having a denominator of two figures. When 2W is approximated to a fraction having a denominator of two figures or less, 3 and 22/28 and 3 and 33/42 are also the most approximate values, but these number are reduced to 3 and 11/14, so that a value of M_2 is 14 in this case.

[0043]

The value of M_2 described above is varied in a range of 4 to 40, whereby filter cartridges having various accuracy can be prepared even if the same non-woven fabric strip is used. Further, it can also be combined with a method of varying a width, a basis weight or a fiber diameter of the non-woven fabric strip.

A deep layer-filtering structure of the filter cartridge can further be optimized by winding the non-woven fabric with M_2 set to a specific value until the major

diameter becomes a certain degree, and by further winding the non-woven fabric with the value of M_2 changed.

[0044]

In the filter cartridge of the present invention, the non-woven fabric strip is wound around the perforated cylinder 2 with the prescribed winding number described above to form a filter cartridge having a major diameter 1.5 to 3 times as large as that of the perforated cylinder. Even when wound in the same winding number, a space between the non-woven fabric strips is varied depending on a major diameter of the perforated cylinder 2. A major diameter of the perforated cylinder 2 is usually decided according to use conditions, and the filtering performance is not controlled by a major diameter of the perforated cylinder 2. If the winding number is the same, as the major diameter of the filter cartridge becomes larger, the particle diameter of the initial particles trapped on the filter cartridge becomes smaller.

[0045]

A width of the non-woven fabric strip used for the filter cartridge of the present invention is preferably 0.5 to 40 cm. If this width is less than 0.5 cm, the wide non-woven fabric is likely to be broken when the non-woven fabric is slit into strips, and it is difficult to control a tension in winding around a perforated cylinder in a twill form. Further, when preparing a filter cartridge having the same void rate, the winding time is extended and the

productivity is reduced. On the other hand, if the width exceeds 40 cm, a friction in a yarn passage of a winder including a traverse guide may be larger or the converged non-woven fabrics may be irregular in size.

[0046]

A basis weight of the non-woven fabric strip, i.e., a weight per unit area of the non-woven fabric is preferably 5 to 200 g/m^2. If the value is smaller than 5 g/m^2, the non-woven fabric may be greatly uneven, reduced in strength or difficult to bond fiber intersections with heat due to lacking in the fiber amount. On the other hand, the value larger than 200 g/m^2 will render the rigidity of the non-woven fabric too much increased, so that the fabric is difficult to wind around a perforated cylinder in a twill form at the later stage.

[0047]

The upper limit of the width in a non-woven fabric strip depends upon the basis weight. The product of the width (cm) of a non-woven fabric and the basis weight (g/m^2) is preferably 20 to 200 $cm \cdot g/m^2$. On the other hand, unfavorably pulled apart when a wide non-woven fabric is slit into strips. Or it is difficult to adjust the tension when the non-woven fabric strip is wound around a perforated cylinder in a twill form. The value larger than 200 $cm \cdot g/m^2$ will render the rigidity of the non-woven fabric too much increased, so that the fabric is difficult to wind around a perforated cylinder in a twill form, and further

the fabric is difficult to densely wind because it becomes too fat after converging. On the other hand, if the value is less than 20 cm・g/m2, the fabric may be broken.

[0048]

The non-woven fabric strip used in the present invention is preferably a long fiber non-woven fabric, a melt blown non-woven fabric or a laminated non-woven fabric thereof, in which at least a part of fiber intersections thereof is thermally bonded. Among them, preferred is the long fiber non-woven fabric in which at least a part of fiber intersections thereof is thermally bonded.

[0049]

In particular, a non-woven fabric obtained by a spun bonding method is preferred as the long fiber non-woven fabric described above. The spun bonding method is a non-woven fabric production technique in which a thermoplastic fiber discharged from a nozzle is sucked and drawn by an air gun, spread on a conveyor and then thermally bonded. The long fiber non-woven fabric comprising thermoplastic fibers produced by the spun bonding method has a fiber direction aligned along a machine direction as shown in Fig. 3, so that a hole constituted by fibers 8 becomes long and narrow, and a maximum size of the passing particle 7 is rather small. In contrast with this, a non-woven fabric comprising short fibers obtained by a carding method and the like has a fiber direction not fixed as shown in Fig. 4, so that a hole constituted by fibers 9 has a shape close to a

circle or a square, and a maximum size of the passing particle 7 is larger than that of a long fiber non-woven fabric produced by the spun bonding method, even the two has the same fiber diameter and void rate.

[0050]

The liquid-passing property of a filtrating material in a filter cartridge almost depends on the void rate when the fiber diameter is identical, and therefore a filter cartridge having an excellent liquid-passing property can be obtained if a long fiber non-woven fabric produced by a spun bonding method is applied. This effect is reduced if such a binder as adhesive is used because it covers in the voids. Accordingly, undesirable is use of a cellulose spun bonded non-woven fabric. Further, as use of a cellulose spun bonded non-woven fabric reduces the strength of the non-woven fabric, it is a problem that the holes constituted by fibers are liable to change shape in the case when the filtration pressure is elevated due to clogging of the filter.

[0051]

An average fiber diameter of the above long fiber non-woven fabric varies depending on uses of the filter cartridge and kinds of the resin, and is preferably 9 to 680 μm. If the value exceeds 680 μm, the long fiber non-woven fabric is only a bundled yarn, and therefore it is meaningless to use the long fiber non-woven fabric. If the value is 9 μm or more, the non-woven fabric has a sufficient

strength and the filter cartridge obtained therefrom has preferably a large strength. If one intends to produce fibers having an average fiber diameter of less than 9 μm by the conventional spun bonding method, it is difficult to make a nozzle for such a use and spinnability is deteriorated, as a result, the cost of the spun bonded non-woven fabric thus produced increases.

[0052]

Yarns constituting non-woven fabric strip have not necessarily a circular cross section. Yarns having profiled cross sections can be used. They can provide a filter cartridge having the same liquid-passing property and a higher accuracy, as compared with the fibers having a circular cross section, because an amount of trapped fine particles increases as a surface area of the filter becomes larger.

[0053]

The methods mentioned above are used for thermal bonding method of fiber intersections in the long fiber non-woven fabric. Among them, a method using a thermal embossing roll is preferred, because it can elevate a production rate of a non-woven fabric, provides a good productivity and can reduce a cost.

As shown in Fig. 5, the long fiber non-woven fabric produced by the method using a thermal embossing roll has part 10 where strong thermal compression bonding by an embossing pattern is applied and part 11 where only weak

thermal compression bonding by deviating from an embossing pattern is applied. This makes it possible to trap a lot of foreign matters 12 and 13 in the part 10, and a part of the foreign matters in the part 11, while the remaining foreign matters can pass through the non-woven fabric to move to the following layer. Preferred is this deep layer-filtering structure, in which even the inside of the filter is utilized.

[0054]

In the present invention, a melt blown non-woven fabric can be also used for a non-woven fabric strip in the filter cartridge. The melt blown non-woven fabric as the non-woven fabric strip has a higher fineness than that of the long fiber non-woven fabric, and the texture thereof can easily be homogenized. Accordingly, the resulting filter cartridge can be improved in a filtering accuracy. An average fiber diameter of the above melt blown non-woven fabric varies depending on uses of the filter cartridge and kinds of the resin, and is 0.5 to 1000 μm, preferably 1 to 50 μm. If the average fiber diameter is less than 0.5 μm, it is difficult to produce the non-woven fabric, which may result in a high-cost filter cartridge. On the other hand, the average fiber diameter exceeding 1000 μm expands a distribution of the fiber diameter and deteriorates a texture of the resulting non-woven fabric. Further, the average fiber diameter exceeding 50 μm may allow the adjacent fibers to bond each other by remaining heat, but it makes no difference

especially as long as it does not prevent the effects of the present invention.

[0055]

In the filter cartridge of the present invention, it may allow to use a non-woven fabric obtained by laminating the above long fiber non-woven fabric and melt blown non-woven fabric at least to two layers for the non-woven fabric strip. In this case, it is possible to take advantage of profit from both the long fiber non-woven fabric and melt blown non-woven fabric. Particle trapping ability of a filter cartridge depends on a fiber diameter of a melt blown non-woven fabric. Accordingly, it is preferred to use this fabric for obtaining a filter cartridge having a high accuracy.

[0056]

In the filter cartridge of the present invention, a dividable fiber can be used for a fiber of the non-woven fabric strip. However, it is difficult in realty to divide the dividable fiber uniformly, so it is preferred to use a melt blown non-woven fabric having a similar average fiber diameter.

[0057]

When the non-woven fabric strip is made hydrophilic by incorporating a hydrophilic resin such as polyvinyl alcohol into a raw material resin for the fabric or subjecting the surface thereof to plasma treatment, the liquid-passing property of the resulting filter cartridge can be enhanced

in case of filtering an aqueous solution. Accordingly, a filter cartridge using such resin is preferred for filtering an aqueous solution.

[0058]

In the present invention, the filter cartridge has a void rate preferably in a range of 65 to 85%. The value smaller than 65% will render the fiber density too high, so that the liquid-passing property is reduced. On the contrary, the value larger than 85% will render the strength of the filter cartridge reduced and often cause deformation of the filter cartridge unfavorably when a high filtering pressure is applied.

[0059]

In the present invention, an end face of the filter cartridge may preferably be smoothened by heat adhesion, which forms smooth end-sealing parts at both ends of the filter cartridge and elevates the sealing property. The non-woven fabric strip constituting both end faces of the filter cartridge is molten by heat, a solvent, a supersonic wave, etc. and then solidified while forming the smooth end faces. Since the non-woven fabric strip comprising the thermoplastic fiber is used in the present invention, a heating method is preferred.

[0060]

[Examples]

The present invention shall be explained below in detail with reference to examples and comparative examples,

but the present invention shall not be restricted to these examples. In the respective examples, the winder is used what is described below, and the physical properties and the filtering performances of the filters were evaluated by the methods described below.

[0061]

(1) Winder and Winding number

A winder had a traverse width (width of traversing) of 250 mm, in which a hole of a traverse guide 6 shown in Fig. 2 had a diameter of 5 mm. An initial speed of a bobbin was set up to 1500 rpm. A winding number (W), that is, a number of winding the non-woven fabric strip around a perforated cylinder from one end to the other end was controlled by interlocking a reciprocating motion of the traverse guide with a rotary motion of the perforated cylinder by means of several gears having an appropriate number of gear teeth.

[0062]

(2) Basis weight and thickness of non-woven fabric

The non-woven fabric having the area of 500 cm^2 was cut off and weighed. The weight was converted to a weight per square meter to define a basis weight. Further, the thickness of the cut non-woven fabric was measured optionally at 12 points, and the values of 10 points excluding the maximum value and the minimum value were averaged to define the thickness of the non-woven fabric. The thickness at the respective points was measured on the conditions of a load of 19.6 Pa and a measuring speed of 2

mm/sec by means of "Digithickness Tester (trade name)" manufactured by Toyo Seiki Seisaku-Sho, Ltd.

[0063]

(3) Average fiber diameter of fiber constituting non-woven fabric

The non-woven fabric was sampled at 5 spots at random, and they were photographed through a scanning type electron microscope. 20 fibers per spot were selected at random to measure the diameters of the fibers, and an average value thereof was defined as the average fiber diameter (μm) of the non-woven fabric.

[0064]

(4) Void rate of filter material for filter cartridge

The major diameter, the minor diameter, the length and the weight of the filter cartridge were measured to determine the void rate using the following equation. In order to determine the void rate of the filter material itself excluding a perforated cylinder, the major diameter of the perforated cylinder was used for the value of the minor diameter of the filter cartridge, and a value obtained by deducting the weight of the perforated cylinder from the weight of the filter cartridge was used for the value of the weight:

(Apparent volume of filter material) = {(Major diameter of filter material)^2 − (Minor diameter of filter material)^2} / 4 × π × (Length of filter material);

(Real volume of filter material) = (Weight of filter material) / (Density of raw material of filter material); (Void rate of filter material) = {1 - (Real volume of filter material) / (Apparent volume of filter material)} × 100 (%).

[0065]

(5) Initial trapped particle diameter and initial pressure loss

One filter cartridge was mounted to a housing of a circulating type testing machine for filtering performance, and water was passed to circulate, controlling a flow rate to 30 dm^3/minute by means of a pump. A difference in pressures at the inlet and outlet of the filter cartridge was set as an initial pressure loss. Next, a cake prepared by mixing 7 kinds of testing powder I prescribed in JIS Z 8901 (1995) (abbreviated as JIS 7 kinds; intermediate diameter: 27 to 31 μm) was continuously added at 0.2 g/minute, and the original solution and the filtrate were sampled 5 minutes after starting of the addition. They were diluted to appropriate concentrations, and then the numbers of particles contained in the respective solutions were measured by means of a light shielding type particle detector to calculate an initial trapping efficiency. Further, the value thereof was interpolated to determine a particle diameter showing a trapping efficiency of 80%, which was defined as the initial trapped particle diameter.

[0066]

(6) Deformation of filter cartridge

One filter cartridge was mounted to a housing (transparent) of a circulating type testing machine for filtering performance, and water was passed to circulate, controlling a flow rate to 30 dm^3/minute by means of a pump. An appearance of the filter cartridge was photographed. The JIS 7 kinds were added until the pressure loss before and after the housing reached 0.5 MPa. Then, an appearance of the filter cartridge was photographed on the same conditions (object distance, magnification, etc.) when the pressure loss before and after the housing reached 0.5 MPa. The major diameter of the filter cartridges shown in the two photographs was measured by image analysis to determine a shrinkage percentage. A shrinkage less than 10% was judged good and shown by "A"; a shrinkage 10% or more and less than 20% was judged fair and shown by "B" and a shrinkage 20% or more was judged poor and shown by "C".

[0067]

Example 1

Used as a non-woven fabric was a polypropylene long fiber non-woven fabric obtained by a spun bonding method. The fiber intersections were thermally bonded by a thermal compression bonding method by means of a heat embossing roll. The non-woven fabric had a basis weight of 22 g/m^2, a thickness of 200 μm and an average fiber diameter of 17 μm. The long fiber non-woven fabric was slit to a width of 50 mm to prepare a non-woven fabric strip. Further, used for a

perforated cylinder was a polypropylene injection-molded article having a minor diameter 30 mm, a major diameter of 34 mm and a length of 250 mm, and also having 180 holes of 6 mm square. A winding number (W) of a winder was set up to 3.1875 (M_2 in the equation (3) is 8 in this case). The non-woven fabric strip was passed through a hole of a traverse guide in the winder and converged, and it was wound around the perforated cylinder until a major diameter reached to 60 mm to obtain a cylindrical filter cartridge. Both end faces thereof were welded by heating for 5 seconds by means of a hot plate having a surface temperature of 175°C to obtain a cylindrical filter cartridge as shown in Fig. 1. Neither bubbling nor falling of the filter material was observed and the pressure loss was small, and thus, the filter cartridge was proved excellent.

[0068]

Examples 2 to 6

Cylindrical filter cartridges were obtained in the same manner using the same non-woven fabric strip and perforated cylinder as in Example 1, except that the winding numbers (W) were set to 3.2778 (Example 2), 3.2917 (Example 3), 3.3847 (Example 4), 3.4118 (Example 5) and 3.1885 (Example 6), respectively. When the 2-fold values (2W) of these winding numbers (W) are approximated to fractions having denominators (M_2) of two figures or less, the denominators are 9, 12, 13, 17 and 61, respectively. As these filter cartridges had larger M_2, the initial trapped

particle diameters became smaller. Accordingly, the value of M_2 correlates with the initial trapped particle diameter. When 2W are approximated to fractions having denominators (M_3) of three figures or less, the initial trapped particle diameter does not decrease in proportion to the denominator (M_3). For example, M_3 is larger in Example 5 than in Example 6, but the initial trapped particle diameter is smaller in Example 6. Thus, it proves that M_3 in the equation (3) does not correlate with the filtering accuracy. The winding number W is smaller in Example 5 than in Example 6, but the initial trapped particle diameter is smaller in Example 6. Thus, it proves that the initial trapped particle diameter does not increase in proportion to the winding number W. The filter described in Example 6 had a relatively large pressure loss and a little poor liquid-passing property as compared with the other filters.

[0069]

Examples 7 and 8

Cylindrical filter cartridges were obtained in the same manner as in Example 4, except that a width of the non-woven fabric strip was changed to 2 cm (Example 7) or 3 cm (Example 8). These filter cartridges had large initial trapped particle diameters as compared with that of the filter cartridge described in Example 4.

[0070]

Example 9

A cylindrical filter cartridge was obtained in the same manner as in Example 4, except that used as a non-woven fabric strip was a melt blown non-woven fabric having an average fiber diameter of 2 μm, a basis weight of 22 g/m^2 and a width of 5 cm. This filter cartridge had a small initial trapped particle diameter as compared with that of the filter cartridge described in Example 4.

[0071]

Example 10

A cylindrical filter cartridge was obtained on the same conditions as in Example 4, except that used as a non-woven fabric strip was a laminated non-woven fabric obtained by thermal compression bonding by means of a heat embossing roll, which comprised three kinds of non-woven fabrics: a polypropylene long fiber non-woven fabric having a basis weight of 5 g/m^2 and a fineness of 2 dtex which was obtained by a spun bonding method, a melt blown non-woven fabric having an average fiber diameter of 2 μm, a basis weight of 22 g/m^2 and a width of 5 cm, and a polypropylene long fiber non-woven fabric having a basis weight of 5 g/m^2 and a fineness of 2 dtex which was obtained by the spun bonding method. This filter cartridge had a small initial trapped particle diameter as compared with that of the filter cartridge described in Example 4.

[0072]

Comparative Example 1

A polypropylene short fiber having a fineness of 2 dtex, a cut length of 51 mm and a crimp number of 14 was formed by conventional melt spinning, and it was spun to obtain a spun yarn. The spun yarn was wound around the same perforated cylinder as in Example 1 with a winding number (W) set to 3.2252 to obtain a filter cartridge. Both end faces thereof were welded by heating for 5 seconds by means of a hot plate having a surface temperature of 175°C to obtain a filter cartridge. This filter cartridge was uneven on the end face and inferior in a sealing property of the end face. The initial trapped particle diameter thereof was in-between of the initial trapped particle diameters in Examples 4 and 5, but it had a larger pressure loss than those of both Examples 4 and 5 and an inferior liquid-passing property. Further, bubbling and the fibers fallen off the filter material were observed in the filtrate, and therefore, it was not preferred as a filter cartridge.

[0073]

Comparative Example 2

A filter cartridge was obtained in the same manner using the same materials as in Example 1, except that the winding number (W) was changed to 0.6538. The wound non-woven fabric strip was liable to come off this filter cartridge, and it was not suited for a filter cartridge.

[0074]

Comparative Example 3

A filter cartridge was obtained in the same manner using the same materials as in Example 1, except that the winding number (W) was changed to 10.1923. The wound non-woven fabric strip was liable to come off this filter cartridge, and it was not suited for a filter cartridge.

[0075]

Comparative Example 4

Used as a structural fiber for the non-woven fabric strip were short fibers comprising polypropylene and high density polyethylene which were dividable into eight parts in a fiber cross section and had a fineness of 2 dtex and a fiber length of 64 mm. This dividable short fiber was webbed by processing by means of a carding machine, and the webbed matter was processed by means of a heat embossing roll to prepare a non-woven fabric. The non-woven fabric was treated twice by means of a water jet apparatus to divide the fiber into a divided non-woven fabric having a basis weight of 22 g/m^2 and a thickness of 210 μm. The non-woven fabric was slit to a width of 50 mm to prepare a non-woven fabric strip. Further, a winding number (W) of a winder was set up to 3.1875 (M_2 in the equation (3) is 8 in this case). The non-woven fabric strip was passed through a hole of a traverse guide in the winder and converged, and it was wound around a perforated cylinder until a major diameter reached to 60 mm to obtain a cylindrical filter cartridge. Both end faces thereof were welded by heating for 5 seconds by means of a hot plate having a surface

temperature of 175°C to obtain a filter cartridge. The filter cartridge thus obtained had a little reduced filtering accuracy as compared with Example 1. A little bubbling and falling of the filter material were observed in the filtrate, and the pressure loss was large. Further, the filter cartridge was liable to be deformed, and it was judged that its use needs a lot of attention in case of the large pressure.

[0076]

Table 1

	W	Approximation of 2W with denominator of two figures	M_2	Approximation of 2W with denominator of three figures	M_3	Non-woven fabric	Width cm	Basis weight g/cm^2
Example 1	3.1875	6 and 3/8	8	6 and 3/8	8	S	5	22
Example 2	3.2778	6 and 5/9	9	6 and 5/9	9	S	5	22
Example 3	3.2917	6 and 7/12	12	6 and 7/12	12	S	5	15
Example 4	3.3847	6 and 10/13	13	6 and 347/451	451	S	5	22
Example 5	3.4118	6 and 14/17	17	6 and 691/839	839	S	5	22
Example 6	3.1885	6 and 23/61	61	6 and 118/313	313	S	5	22
Example 7	3.3847	6 and 10/13	13	6 and 347/451	451	S	2	22
Example 8	3.3847	6 and 10/13	13	6 and 347/451	451	S	3	22
Example 9	3.3847	6 and 10/13	13	6 and 347/451	451	M	5	22
Example 10	3.3847	6 and 10/13	13	6 and 347/451	451	SMS	5	32
Comparative Example 1	3.2252	6 and 9/20	13	6 and 168/373	373	Spun yarn	0.3	-
Comparative Example 2	0.6538	1 and 4/13	13	1 and 255/829	829	S	5	22
Comparative Example 3	10.1923	20 and 5/13	13	20 and 5/13	13	S	5	22
Comparative Example 4	3.1875	6 and 3/8	8	6 and 3/8	8	Divided yarn	5	22

S : Spun bonded non-woven fabric

M : Melt blown non-woven fabric

SMS: Spun bonded non-woven fabric/melt blown non-woven fabric/spun bonded non-woven fabric

Table 1 (Cont'd)

	Width × basis weight cm × g/cm^2	Void rate %	80% trapped particle diameter µm	Pressure loss MPa	Bubbling	Falling of filter material	Deformation
Example 1	110	85	59	0.003	A	A	A
Example 2	110	82	39	0.004	A	A	A
Example 3	75	76	8.3	0.018	A	A	A
Example 4	110	81	27	0.006	A	A	A
Example 5	110	76	7.5	0.020	A	A	A
Example 6	110	74	5	0.030	A	A	A
Example 7	44	81	28	0.005	A	A	A
Example 8	66	78	17	0.009	A	A	A
Example 9	110	81	20	0.006	A	A	A
Example 10	160	81	20	0.006	A	A	A
Comparative Example 1	-	70	10	0.030	C	C	B
Comparative Example 2	110	-	-	-	-	-	-
Comparative Example 3	110	-	-	-	-	-	-
Comparative Example 4	110	85	50	0.004	B	B	C

[0077]

[Effect of the Invention]

It is evident from Table 1 that the filter cartridge of the present invention is superior to the conventional bobbin winder type filter cartridge in liquid-passing property, and it also has an excellent property that bubbling and particle falling off does not occur though they are observed in the conventional bobbin winder type filter cartridge.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 is a perspective of the filter cartridge according to the present invention.

Fig. 2 is an illustration of winding a non-woven fabric strip with traversing.

Fig. 3 is a conceptual diagram of a spun bonded non-woven fabric.

Fig. 4 is a conceptual diagram of a short fiber non-woven fabric.

Fig. 5 is an illustration of trapping foreign matters by means of an embossing pattern of a non-woven fabric.

[Explanation of Codes]

1: Filter cartridge

2: Perforated cylinder

3: Converged non-woven fabric strip

4: Non-woven fabric strip

5: Bobbin

6: Traverse guide

7: Particle

8: Long fiber constituting spun bonded non-woven fabric

9: Short fiber constituting short fiber non-woven fabric

10: Part where strong thermal compression bonding by an embossing pattern is applied.

11: Part where only weak thermal compression bonding by deviating from an embossing pattern is applied

12: Foreign matters

13: Foreign matters passed through part where only weak thermal compression bonding by deviating from an embossing pattern is applied

[NAME OF DOCUMENT] DRAWINGS

FIG. 1

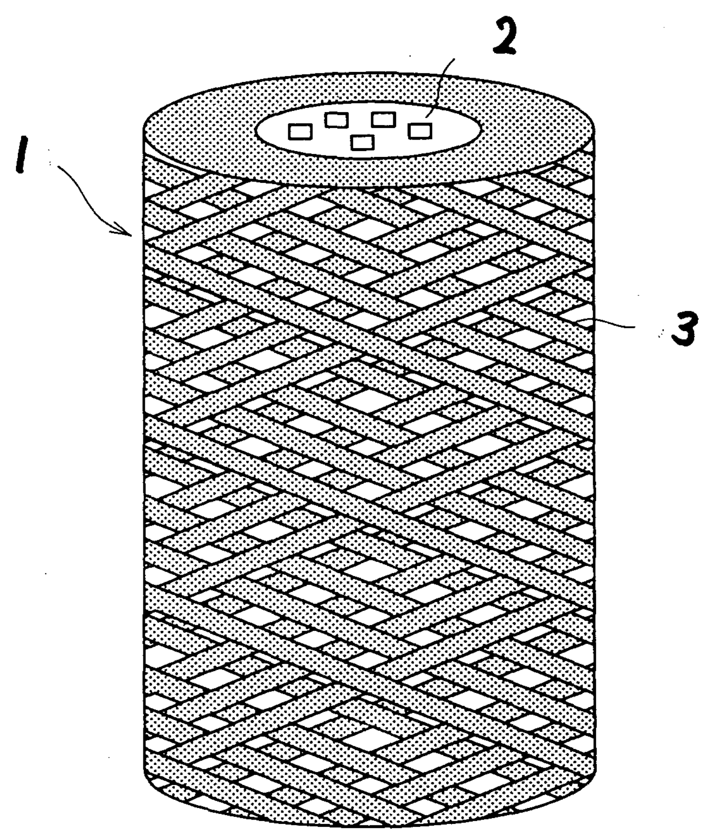


FIG. 2

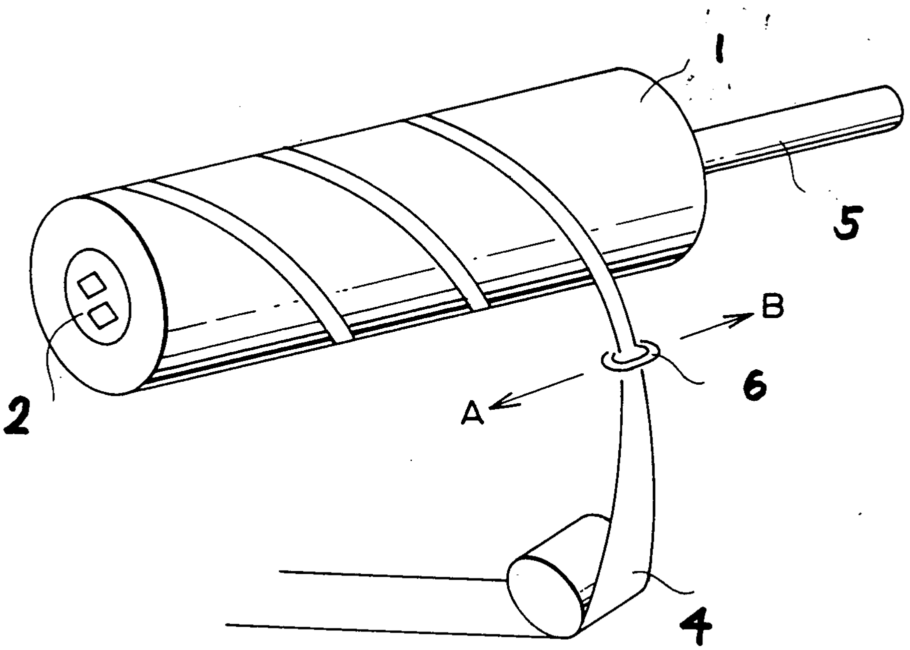


FIG. 3

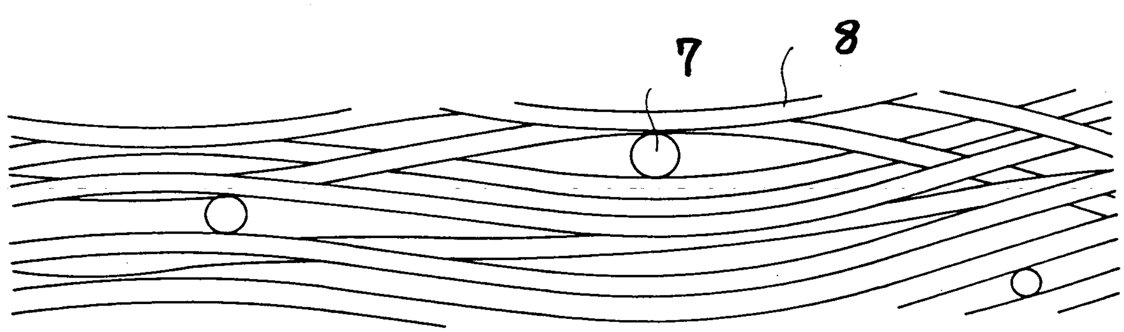


FIG. 4

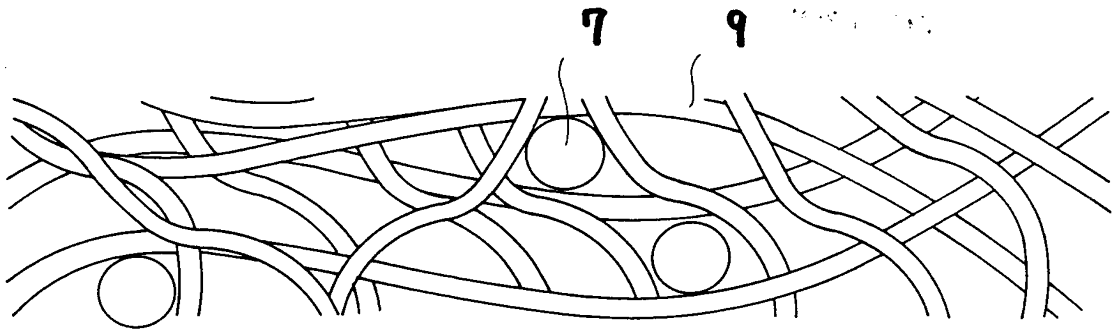
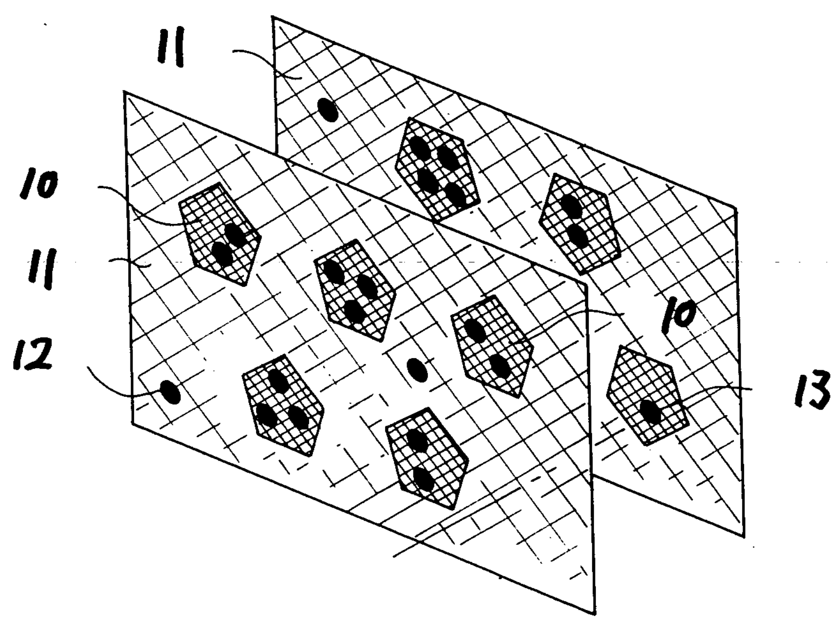


FIG. 5



[NAME OF DOCUMENT] ABSTRACT

[SUMMARY]

[OBJECT] To provide a filter cartridge which is improved in filter life and water-passing property, and further prevented from falling of fiber chips.

[SOLUTION MEANS] A filter cartridge which is prepared by winding a non-woven fabric strip comprising a thermoplastic fiber around a perforated cylinder in a twill form, wherein in winding in a twill form, a number (W) of winding the non-woven fabric strip from one end to the other end in a longitudinal direction of the perforated cylinder is one to 10 per a length of 250 mm in the perforated cylinder, and it is preferable when a 2-fold value (2W) of the winding number (W) is represented by a fraction having a denominator of two figures or less which is a non-reducible approximate value, the denominator is 4 to 40.

[SELECTED DRAWING] none